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Abstraction and Computational Thinking: Possibilities as from the New Brazilian National Common Curricular Basis

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***Keywords*— Abstraction, Computational Thinking, cognitive process, Brazilian school.**

***Abstract*— The most important and highest-level cognitive process on computational thought is the abstraction one. A new regulating norm of the school curriculum in Brazil evokes the more diverse skills, which the adoption of communication and information technologies makes available in the educational process of computational thinking and its dominion on part of the students. This study aimed to clear this configuration in basic education, while taking the demands resulting from the National Common Curricular Basis and computational thinking into account in order to attain the proposed skills. Following up this perspective, we accomplished a bibliographical and documental review which led us into perceiving the computational thinking in the curricular and school environment. In accordance with the research, we then observed there is an appropriate moment in Brazilian education, inclusively of legal order, to work out the computational thinking at school towards allowing the construction of a logical, articulated, systematized and abstract thinking, capable of contributing to the growth of both competencies developed by means of learning to learn, the conscious use and integration and the reflexive forms of the apprehended contents and applied to various daily situations of Brazilian schools.*

I. INTRODUCTION

When telling about computation, we are inexorably telling about abstractions. Therefore, the essence of the computational thinking is abstraction [1]. The automation of the abstract relationships and the information generated by these relationships is the basis of the computer science, which is fundamentally a science of abstraction since it creates models for thinking about problems and for designing appropriate mechanizable techniques for solving them. So, this automation necessarily implies both the knowing subject's coordination and differentiation through which he builds knowledge, like structure or capacity; secondarily, like content. However, the most important and the highest-level computational thinking is the abstraction process [2], [3]. Based on these scholars, we understand thinking ought to refer to all psychic activity, while the set of cognitive phenomena and the abstraction like an operation of the being who, after having distinguished the different characters of an object, separate one of them from the others to consider it in isolation as a thing.

This positioning is confirmed once the computational idea of algorithm itself is linked to the abstraction of a process that receives inputs, executes a sequence of steps and produces outputs to satisfy a desired goal. Therefore, the efficient projection of algorithms intrinsically involves projecting solutions on these abstract data. When we

develop programs in high-level language, for instance, we are basing on low layers of abstractions. The programming languages incorporate many mechanisms of abstraction that allow part of a code to be written once and be repeatedly reused. This abstraction is the key to control the enormous complexity of real programs which consist of several layers of such abstractions. A priori, there is no worry about hardware details, about the operational system, the platform, the system of archives or about the network to carry out this program.

We therefore understand the essences of the computation science and mathematics itself are alike [1], because the primary products of both subjects and the models they build up are abstract. In such case, the mathematics primary products are the structures of inference, while the main IT products are the interaction patterns.

This context pushes us into seeing that abstraction is an indispensable component to the students' cognitive growth, since – in infantile education – children are stimulated to pursue abstractions and generalizations. It is therefore a competency that is being developed as time goes by and, the more it is stimulated, the easier the construction of this competency will be. Contextualized activities are important to arouse attention and relevance [4].

Computational thinking can assist in this process in a playful way, so fomenting the learning to learn that the National Common Curricular Basis (BNCC) defends.

II. COMPUTATIONAL THINKING IN BASIC EDUCATION: THE CONSTRUCTION OF THE LEARNING TO LEARN

Computational thinking represents a thinking process [2] involved in the formulation of a problem and in the expression of its solution in such a way that a human being or a machine can effectively accomplish. A computer program becomes an algorithmic sign which can both be interpreted by humans and machines [5]. The double interpretation allows for a dialectic relationship between computing activities and Computational Thinking instead of the dualistic traditional vs new approach.

Thus, it involves the solution of problems by projecting algorithms as per human understanding, while getting inspired in fundamental concepts of the Computation Science. Although the automation necessarily implies in some kind of computational device for the interpretation of abstractions, the computational thinking does not require a machine and tends to be a fundamental skill such as reading, writing and arithmetic.

Based upon the current importance of the theme, the International Society for Technology in Education [6] published a study that synthesizes the characteristics developed by students using computational thinking. These include (a) a formulation of definitions of problems adjusted to technology-assisted methods, such as data analysis, abstract models and algorithmic thinking to explore and find solutions; (b) the collection of data or identification of sets of relevant data, the use of digital tools to check them up and representing data in many ways to ease the solution of problems and making decisions; (c) the decomposition of problems in component parts, extracting important information and developing descriptive models to understand complex systems or facilitating the solution of problems; (d) understanding how the automation works and the use of algorithmic thinking to develop a sequence of steps to create and test automated solutions.

From these characteristics, we can produce evidence that computational thinking is not restricted to solution of problems, but also to their formulation. We understand that, on observing daily problems, the learner needs to structure a set of problems in order to (re)define it [1], [2], [4]. He will then be able to search for a structured solution. Data handling skill (identification, search, and categorization) is equally required [6].

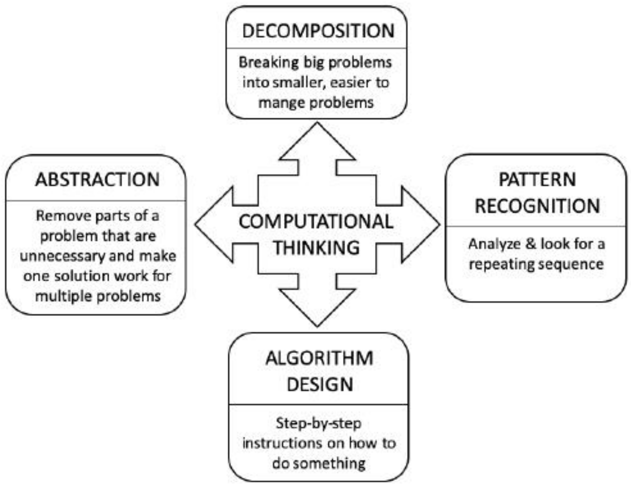

Fig. 1: Elements of Computational Thinking

In school practices, we can see that the student's observation of the physical results, such as putting small lights to work (Light Emitting Diode – LEDs), and the running of engines throughout the Arduino Platform help the teacher to analyze the cognitive process that each student follows up to trace a sequence of steps to create and test his own solutions. Studies show that in Brazil, when applying the principles of computational thinking in

basic education, the most commonly used tools were Scratch, Lego Robots, Arduino, IDE, Code.org, App Inventor, Robocode [7]. Typically, programming courses include hands-on programming activities to allow students to practice and explore computing concepts as part of the learning process [7], [8].

In this aspect and considering the protagonism BNCC attributes to learning to learn [9], it is imperative that – in the early years of Elementary School – programming languages should be used to foster Computational Thinking. In this sense, the document addressed to elementary school explains that, children's experience in their family, social and cultural environment, their memories, their belonging to a group and their interaction with the most diverse communication and information technologies are sources that stimulate their curiosity and the formulation of questions. The stimulation to creative, logical and critical thinking – by means of the construction and the strengthening of the capacity to ask questions and evaluate the answers, discussing, interacting with several cultural productions, making use of communication and information technologies – allows the students to enlarge the understanding of themselves, of the natural and social world, of the relationships of the human beings aid themselves and nature [9].

BNCC itself evokes the most diverse skills allowed by the adoption of the communication and information technologies in the educational process, which denotes the use of computer and, consequently, presupposes the students' dominion of computational thinking.

As the Basis points out, "the social and affective links, the intellectual possibilities and the most abstract thinking capacity get enlarged" in the second step of elementary school. Still in accordance with the document, it is imperative that the school understands and incorporates more the new languages and their working methods, unraveling communication possibilities (and handling, as well), and that it may educate for more democratic uses of technologies and for a more conscious participation in the digital culture. In taking advantage on the digital communication universe potential, the school may institute new ways to promote learning, interaction and the sharing of meanings among teachers and students [9].

In view of the above, it becomes clear that it is important to think of new ways of teaching so that students may develop the practice of learning to learn in his schooling process, since the first steps in basic education.

As far as high school is concerned, this skill becomes even more pressing. The World Economic Forum – WEF (non-profit organization created to discuss the world's most urgent issues) [10], there is a growing demand for skill involving computational thinking in the labor world. Yet, to guarantee a solid formation to understand and apply computational thinking for all, this learning ought to be started in the early years of childhood.

Next, we present a chart in which the demands for skills required of the professionals trained for today's society – present in the WEF document – are explained [10].

Table.1: Main demands for skills in 2018 versus 2022

2018	2022
- Analytical thinking and innovation	- Analytical thinking and innovation
- Solution of complex problems	- Active learning and learning strategies
-Critical thinking and analysis	- Creativity, originality and drive
- Creativity, originality and drive	- Design and technology programming
- Attention to details, reliability	- Complex solution of problems
- Emotional intelligence	- Social influence and leadership
- Reasoning, resolution of problems, ideation	- Emotional intelligence
-.Social influence and leadership	- Reasoning, resolution of problems, ideation
- Time and coordination management	- Analysis and evaluation of systems

The skills listed in the chart above show that the school cannot be restricted to go on working the contents without taking the current society complexity into account.

III. THE NATIONAL COMMON CURRICULAR BASIS AND COMPUTATIONAL THINKING IN HIGH SCHOOL

The National Common Curricular Basis comes to meet a yearning that has been generated since the Promulgation of the Federal Constitution of 1988, article 210 of which provides fixed contents to be studied in Elementary School. The aforementioned article explains that: "Minimum contents are fixed for elementary education, so as to ensure basic education and respect for national and regional cultural and artistic values".

As from this understanding and after several discussions, including quite divergent ones, the one tried by the National Council of Education (NCE) and BNCC – referring to High School – was approved. The

homologation by the Ministry of Education (MEC) happened on December 14, 2018. The document aims to guarantee integral formation of individuals through the development of skills of the 21st century. MEC executive management defended that the competencies of the 21st century have to do with the formation of more criticism-imbued citizens, with the capacity of learning to learn, of solving problems, of being autonomous to make decisions, citizens that are capable of working in team, respecting the other, the plurality of ideas, having the capacity to argue and defend their viewpoint. Furthermore, today's society itself imposes a new look at the central issues of education, in particular: what to learn, what to learn for, how to teach and evaluate learning.

Despite the most varied criticisms of the educational bodies, BNCC seeks to unify basic contents that shall be taught all over the country. These ought to integrate the compulsory minimum curriculum of all schools, also contemplating the traditional and regional teachings, which correspond to the diversified school curriculum. Therefore, schools can add what is typical of each community to their Pedagogical Political Project (PPP), without dispensing with the minimum contents provided by the BNCC.

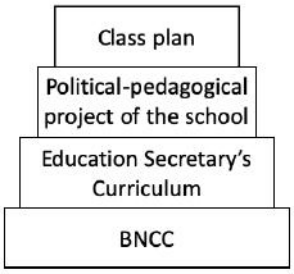

Fig. 2: Documents related to the Brazilian educational curriculum

According to the Basis, the students are supposed to develop cognitive and socio-emotional competencies through basic education. Among the ten competencies mentioned in the document, we highlight those in which computational thinking can contribute in a more effective way.

- To exercise the intellectual curiosity and seek the appropriate approach to sciences, including investigation, reflection, critical analysis, imagination and creativity, to investigate causes, elaborate and test hypothesis, formulate and solve problems and produce solutions (inclusive, technological ones) based upon knowledge of different areas

- To use different languages – verbal (oral or visual-motor such as Sign Language, and writing), body, visual, sound and digital as well as knowledge about artistic, mathematical, scientific languages, to express oneself and share information, experiences, ideas and feelings in different environments and to produce meanings that lead to mutual understanding.

- To understand, to use and create digital technologies of information and communication in a critical, meaningful, reflexive and ethical way in the various social practices (inclusive, school ones) to communicate, access and disseminate information, to produce knowledge, solve problems and exercise protagonism and authorship in personal and collective life.

- To argue based on trustworthy facts, data, information, to formulate, negotiate and defend ideas, viewpoints and common decisions respecting and promoting human rights, socio-environmental consciousness and responsible consumption at local, regional and global levels, with ethical positioning in relation with self-care, other people's and the planet's.

BNCC has organized the contents in four areas of knowledge: (a) Languages and their Technologies; (b) Mathematics and its Technologies; (c) Sciences of Nature and its Technologies; and (d) Applied Human and Social Sciences. The Ordinance # 1432/2018 establishes that the high school curricula must be composed of two parts: the general basic formation, with a total working load of max. 1,800 hours and the forming itinerary, with total working load of at least 1,200 hours, as from four structuring axles: Scientific Investigation, Creative Processes, Mediation and Socio-cultural Intervention and Entrepreneurship.

In these molds, the High School reform and BNCC have created forming itineraries and have changed them into fertile fields for the development of computational thinking, reverberating in the construction of new curricula and new ways of learning and teaching. For instance, among specific skills in the structuring axis of Creative Processes – linked to the Sciences of Nature area ad their Technologies – there appear the abilities to propose and test ethical, esthetic, creative and innovating solutions to real problems, considering the application of design of solutions and the use of digital technologies, computational programming and/or thinking to support the construction of prototypes, devices and/or equipment, aiming to better the quality of life and/or the production processes.

We perceive that computational thinking becomes a fundamental tool to attain such competencies and, up to certain extent, it facilitates the consecution and the attainment of the expected formation for this teaching level.

IV. CONCLUSION

The present world offers students unprecedented opportunities and powerful tools to develop various literacies [11]. The Computational Thinking began to influence on subjects and professions further to science and engineering, among which study areas one finds medicine, economics, finances, law, social sciences, archeology, arts, humanities and journalism.

Today's society has substantially changed its way of thinking and acting as regards its interaction with the social world. This interaction has been measured through digital technologies, on daily basis. However, projects for implementing Information Technology in Teaching (ITE) do not achieve the expected success because they concentrate all the effort on specific elements, not focusing on a systemic view that enables to enhance the use of that technology [12]. The teachers do not use digital technologies in their practice satisfactorily, but are constantly connected; are motivated by peers, pupils, official documents and pedagogical coordination; there are policies to promote the insertion of TDICs in the classroom and that the scientific literature on emerging technologies in education is still very recent, with no specifications of the technologies, their educational applications and objective evaluation criteria [13].

The computer has become a founding ally to the social interaction processes, as well as to the formative and productive ones. Yet, the school is in disarray with this change. In this direction, public policies for education need to take a proactive stance, fomenting a rethinking of attitudinal and procedural feature to attain the conceptual contents and, consequently, a wider formation.

Countries such as South Africa, Russia, Australia, New Zealand, and have already made room for CS in the K–12 curriculum [14]. In Brazil, the BNCC intends to unify and equalize the basic-school students' formative process, aiming to attain quality in Brazilian education. In this context, it brings an apologetic discourse to the use of digital technologies, as one of the paths capable of assisting to reach this quality. Computational thinking is not seen only as a static tool to be handled by teachers. On the contrary, it appears as a possibility of constructing a logical, articulated, systematized abstract thinking, capable of contributing for the growth of wide competencies, developed throughout the learning to learn, the integration and its conscious use and, in a reflexive way, the apprehended contents and applied to diverse daily situations. That is, if well developed since the first steps in basic education, computational thinking can contribute to break down barriers of cognitive order and to promote a more inclusive teaching.

We understand such a reality is not easy to be attained, and that computational thinking cannot modify Brazilian education in its more varied gaps, but believe we shall seek solutions to reach equity in the search for learning and allow a more qualified education, impacting on students of all the Brazilian regions. Thus, computational thinking can be contributory as one of the many links of this chain of good.

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